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Basal metabolic rate and energy expenditure of pregnant Nigerian women

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The purpose of the present study was to compare basal metabolic rates (BMR) of pregnant Nigerian women from rural and urban areas with values from similar studies in other Third World countries. We also investigated possible changes in BMR during the course of pregnancy. An open-circuit indirect calorimeter was used to measure BMR and energy expenditure (EE) during sedentary activity in forty-one pregnant Nigerian women. The results showed marked variability in BMR among individuals. A correlation analysis between BMR and other biological and physical characteristics revealed body-weight and gestation as the only variables related to BMR and oxygen consumption.

The study revealed no significant difference between BMR and EE of sedentary activity in the subjects. The wide variability may have been due to the nutritional status of the subjects studied, who were drawn largely from the lower socioeconomic groups of Nigerian society. The present study shows that socioeconomic status and nutritional interventions should be taken into account when framing recommendations for maternal nutrition during pregnancy.

Basal metabolic rate: Energy expenditure: Pregnancy

Famine and poverty contribute significantly to the low energy and poor dietary intakes of many people in the Third World. As Waterlow (1987) has aptly remarked, 'the underlying cause of malnutrition in the Third World is poverty (which) can only be eliminated by political and economic changes'. Nigeria is a Third World country, and poverty and hunger are serious problems facing many people in both rural and urban areas.

Pregnancy is usually accompanied by, among other changes, a considerable increase of metabolically active tissues. Other important physiological changes include: the growth of the fetus and the placenta, an enlargement and hypertrophy of the organs of reproduction and increases in the volumes of circulating blood and other body fluids. Since the present study is concerned specifically with basal metabolic rate (BMR), and energy expenditure (EE) of pregnant Nigerian women, it should provide information useful for predicting and prescribing the energy and nutritional requirements of such women.

This is, to the best of our knowledge, the first study dealing with the BMR and energy cost of activity in pregnant Nigerian women, although Cole & Ogungbe (1987) investigated the food intake and EE of female Nigerian students. Indeed, there are very few studies on the BMR of pregnant women in Africa as a whole, or the Third World generally. The few reported studies have indicated that BMR values for African women are lower than those for their counterparts in the Western world (Lawrence *et al.* 1986).

Lawrence *et al.* (1984), in their study of pregnant women in The Gambia, produced some convincing evidence for metabolic adaptation when they observed a fall in their subjects' BMRs which they suggested may have been due to effective metabolic adaptation to increased energy demands. Maletnlema & Bavu (1974) had earlier studied the nutritional status of seventy pregnant Tanzanian women from Kisirawe, using weighing and recall methods to estimate the dietary intakes of their subjects. Working with Indian women, De

& Nagchaudhuri (1975) reported an increased mean BMR in 100 pregnant women. The increase was of the order of 5–6% during the third trimester. Dakshayani & Ramanamurity (1964) had earlier reported a similar increase between the second and third trimester in pregnant Indian women.

The weight gain during pregnancy in developed countries is about 12·5 kg, and median infant birth weight is 3·3 kg (coefficient of variation 15%) (Hytten, 1980). For a typical pregnancy, the average energy cost has been calculated to be about 335 MJ (80000 kcal) over the 9-month period. This is distributed, according to the report of the Food and Agriculture Organization/World Health Organization (1973), as an extra 630 kJ (150 kcal)/d during the first trimester and 1465 kJ (350 kcal)/d during the second and third trimesters. Banerjee *et al.* (1971) found that in pregnant Chinese, Malay and Indian women the BMR was 27% higher, but body-weight only 13% higher, than in non-pregnant women.

MATERIALS AND METHODS

The forty-one pregnant women (age range 18–40 years) who took part in the study were randomly selected from among those registered at the antenatal clinic of the University College Hospital (UCH), Ibadan. They were of low and medium socioeconomic status from the rural and urban areas of Ibadan, Oyo State of Nigeria, and were engaged in subsistence farming, some small-scale trading or certain semi-skilled jobs. Efforts were made to select pregnant women in the early and later stages of pregnancy, and none had ever smoked.

The Ethical Committee of the College of Medicine, University of Ibadan had approved the project, and the informed consent of the participants was sought and obtained before the study began.

At 1 d before the measurements, the subjects were admitted to the antenatal ward of the hospital (UCH). This was to enable us to comply strictly with the standardized requirements for measuring BMR: that subjects be under standardized resting conditions, that they be bodily and mentally at rest, that measurements be taken 12–14 h after the subjects' last meal and that measurements take place in a thermoneutral environment. The BMR was measured between 06·30 and 07·30 hours, more than 12 h after the subjects had had their last meal. They had also had at least 8 h sleep. EE was measured later, with the women sedentary.

Measurement of BMR

Indirect calorimetry was used to measure the BMR of the forty-one subjects.

Respiration-gas meters of the Max Planck Institute for Work Physiology, Dortmund, developed in Germany, modified by Müller & Franz (1952) and manufactured by Gesellschaft für Gerätebau (Dortmund, West Germany), combined with face masks, were used to measure the volume of expired air ($\dot{V}_E$). The respirometer was calibrated as described by Cole (1976). The face masks were in three different sizes. They were manufactured by Volkseigener Betrieb Kombinant Medizin und Labor Technik, Leipzig, GDR. To suit our physiological purpose, the face masks were modified in the workshop of the Central Institute of Nutrition, Academy of Sciences of GDR, Potsdam-Rehbrücke.

Each subject breathed through a face mask via a corrugated tube to the respirometer and from thence to an inflatable rubber bag; this was placed inside a plastic sack which was filled with expired air to prevent changes in the gas content of the gas bladder (Rahaman & Durnin, 1964) before analysis. $\dot{V}_E$ and temperature (using the thermometer in the respirometer) of expired air were recorded. Air pressure was measured using a barometer.

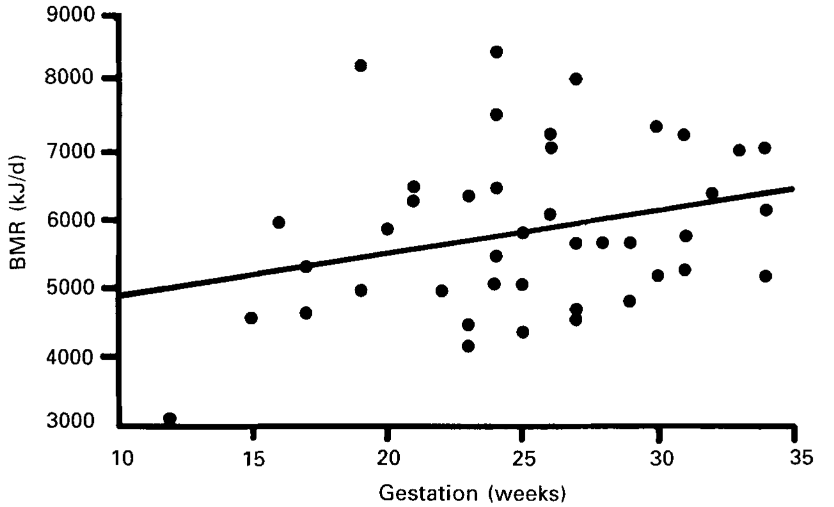

Fig. 1. Scatter diagram of relation between basal metabolic rate (BMR, kJ/d) and gestation (weeks). ($Y = 4236 + 64{\cdot}8\ X$; r 0·28, $P < 0{\cdot}05$.)

The measured gas volume was corrected to standard temperature and pressure and the volume of inspired air was derived from $\dot{V}_E$ and the gas concentrations. The oxygen and carbon dioxide concentrations of the mixed expired gas sampled by the inflatable bag through the respirometer were measured using a polargraphic O_2-analyser (Medical Analyser OM-11; Beckmann) and an infrared absorption CO_2 analyser (Medical Analyser LB-2; Beckmann). Both analysers were calibrated regularly with a certified gas mixture of O_2, CO_2 and nitrogen (19·9:4·1:76, by vol.) (BOC, London).

Measurement of EE while sitting quietly

EE was measured following the same procedure as in the measurement of BMR. This time, however, the subjects were in a sedentary position, had had breakfast and measurements took place between 08·30 and 09·30 hours.

RESULTS

BMR

The mean values for indices of the biological and physical characteristics of the forty-one pregnant women in the study are presented in Table 1 (detailed values in the Appendix). There was a wide variability in BMR among individual subjects at all stages of pregnancy. For example, the highest BMR of 8345 kJ/d was recorded for a woman in her 19th week of gestation, while the lowest BMR of 3121 kJ/d was from a subject in her 12th week of pregnancy.

Analysis of all the variables showed that only body-weight and gestation were significantly correlated with BMR ($P < 0{\cdot}05$); Pearson correlation coefficients were 0·56 and 0·28 respectively. Further analysis of the values showed that the linear equations BMR = 1361 + 73 × body-weight, and BMR = 4236 + 65 × gestation, can adequately describe the relations between BMR and body-weight and BMR and gestation respectively. When BMR was corrected for body-weight, its relation with body-weight was no longer significant ($P > 0{\cdot}05$). The scatter diagram of BMR in relation to gestation is shown in Fig. 1.

Table 1. *Mean values for indices of physical and physiological characteristics of forty-one pregnant Nigerian women*
(Mean values and standard deviations)

Age (years)		Body-wt (kg)		Height (m)		Period of pregnancy (weeks)		PCV		$\dot{V}_{O_2}$ (l/min)		BMR			
												kJ/d		kcal/d	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
27·90	6·1	61·85	9·4	1·60	0·061	25·32	3·0	0·345	0·028	0·203	0·05	5876	1226	1404	1·5

PCV, packed cell volume; $\dot{V}_{O_2}$, oxygen consumption; BMR, basal metabolic rate.

EE

There was no significant difference between BMR and EE in the sedentary condition ($P > 0.05$). The forty-one subjects had a mean O_2 consumption of 0·220 (SD 0·81) l/min, respiratory quotient 0·81 (SD 0·11) and mean EE of 4·44 (SD 1·29) kJ/min (0·95 (SD 0·31) kcal/min).

DISCUSSION

The differing socioeconomic status of the subjects (see p. 632) and the varying levels of their normal activities are plausible explanations for the wide variability in BMR. It is quite reasonable to expect EE to bear some relation to nutritional status and to the degree (heavy or light) of the physical activity of the subjects. This seems to have been the case in the present study, resulting in the wide variability already noted in the BMR. Another possible reason could be the method used for the measurement of BMR. However, in the present study, in which the standardized method was strictly followed, variability would not seem to be attributable to methodology.

It can also be argued that differences in the proportion of lean body mass among individuals with different levels of energy and dietary intake, coupled with the fact that small differences do exist in the mass of metabolically active organs, could have contributed to the wide variability observed. Ferro-Luzzi (1986), for example, made a similar suggestion. Since the subjects in the study were obviously of ample body size, it is difficult to assess to what extent variability in BMR was due to differences in the proportion of lean body mass or metabolically active mass. We did not determine the body composition of the subjects in the present study.

Despite the wide variability in BMR found in the present study, our results are comparable with information on BMR obtained for women in The Gambia, India, China, Thailand and the Philippines. Basal EE of the subjects in this study does not differ significantly from values reported by Lawrence *et al.* (1984), Khan & Belavady (1973), De & Nagchaudhuri (1975), Banerjee *et al.* (1971), Dakshayani & Ramanamurity (1964), Durnin (1982) and Blackburn & Calloway (1976, 1985). However, our values are slightly higher than those reported by Banerjee *et al.* (1971), Khan & Belavady (1973), De & Nagchaudhuri (1975) and Lawrence *et al.* (1984).

In conclusion, the present paper presents useful information for policy makers and nutrition scientists in Nigeria. The wide variability among individuals at all stages of pregnancy might be due to the nutritional status of the subjects studied, which are largely from a low socioeconomic group. Durnin (1982) indicated that women can have normal pregnancies and breast-feed their children even though their nutrient intakes are far below recommended levels. If we accept Durnin's (1982) suggestion, there is a strong possibility that because of cultural and physiological adaptations the nutritional requirements of some pregnant and lactating women may not be much greater than those of non-pregnant women. We should like to reiterate that previously there was no information on BMR and EE of Nigerian women at various stages of pregnancy. The published information currently available from other African countries, such as The Gambia, is inadequate and does not constitute an adequate basis to enable the Nigerian nutritionist to advise the appropriate authorities in prescribing adequate dietary and energy allowances for pregnant women in Nigeria.

It is, therefore, recommended that in order to generate this much-needed information, the present study should continue on a longitudinal basis to include such topics as: food intake, EE of activity, body composition (anthropometry) and multiple measurements of the subjects throughout pregnancy.

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REFERENCES

Banerjee, B., Khawa, K. S. & Saha, N. (1971). A comparative study of energy expenditure in some common daily activities on non-pregnant and pregnant Chinese, Malay and Indian women. *Journal of Obstetrics and Gynaecology of the British Commonwealth* **78**, 113–116.

Blackburn, N. W. & Calloway, D. H. (1976). Basal metabolic rate and work energy expenditure of mature pregnant women. *Journal of the American Dietetic Association* **69**, 24–28.

Blackburn, N. W. & Calloway, D. H. (1985). Heart rate and energy expenditure of pregnant and lactating women. *American Journal of Clinical Nutrition* **42**, 1161–1169.

Cole, A. H. (1976). Untersuchungen zum Energieumsatz bei normalgewichtigen und adipösen Persönen als Beitrag zum problem Ernährung und Leistung und als theoretisch-methodische Voraussetzung entsprechender Untersuchungen unter tropischen Bedingungen. Inaugural Dissertation, Akademie der Wissenschaften der DDR, Berlin.

Cole, A. H. & Ogungbe, R. F. (1987). Food intake and energy expenditure of Nigerian female students. *British Journal of Nutrition* **57**, 309–318.

Dakshayani, R. & Ramanamurity, P. S. V. (1964). Basal metabolism and creatinine excretion in different physiological groups. *Indian Journal of Medical Research* **52**, 1159–1164.

De, A. K. & Nagchaudhuri, J. (1975). Studies on basal metabolic rate — pregnant and lactating women in Varanasi. *Indian Journal of Medical Research* **63**, 613–616.

Durnin, J. V. G. A. (1982). Energy requirements of pregnant and lactating women. *Nestlé Foundation Annual Report*, pp. 13–22, 47–62. Vevey: Nestlé.

Ferro-Luzzi, A. (1986). Range of variation in energy expenditure and scope for regulation. In *Proceedings of the XIIth International Congress of Nutrition*, Brighton, pp. 393–399 [T. G. Taylor and N. K. Jenkins, editors]. London: John Libbey.

Food and Agriculture Organization/World Health Organization (1973). *Energy and Protein Requirements*. Technical Report Series no. 522 Geneva: WHO.

Hytten, F. F. (1980). In *Clinical Physiology in Obstetrics*, pp. 193–233 [F. F. Hytten and G. Chamberlain, editors]. Oxford: Blackwell Scientific Publication.

Khan, L. & Belevady, B. (1973). Basal metabolism in pregnant and nursing women and children. *Indian Journal of Medical Research* **61**, 1853–1860.

Lawrence, M. L., Lawrence, F., Coward, W. A., Cole, T. J. & Whitehead, R. G. (1986). Energy expenditure and energy balance during pregnancy and lactation in The Gambia. *Nestlé Foundation Annual Report*, pp. 77–103. Vevey: Nestlé.

Lawrence, M. L., Lawrence, F., Lamb, W. H. & Whitehead, R. G. (1984). Maintenance energy cost of pregnancy in rural Gambian women and influence of dietary status. *Lancet* **ii**, 363–365.

Maletnlema, T. W. & Bavu, J. L. (1974). Nutritional studies in pregnancy. *East African Medical Journal* **51**, 515–528.

Müller, E. A. & Franz, H. (1952). Energie verbrauchsmessungen bei beruflicher mit einer Verbesserten Respirations-Gasuhr. *Arbeitsphysiologie* **14**, 499.

Rahaman, N. M. & Durnin, J. V. G. A. (1964). Changes in concentration of gases in the rubber bladders of Max-Planck respirometers. *Journal of Applied Physiology* **19**, 1188–1191.

Waterlow, J. W. (1987). Discussion on famine, introductory remarks. *Proceedings of the Nutrition Society* **46**, 259–261.

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Appendix. *Physical and physiological characteristics and basal metabolic rate (BMR) of forty-one pregnant Nigerian women at various gestational stages*

Subject no.	Period of gestation (weeks)	Age (years)	Body-wt (kg)	Height (m)	PCV	$\dot{V}_{O_2}$ (l/min)	BMR (kJ/d)
1	12	20	54	1·63	0·36	0·107	3121
2	15	35	75	1·61	0·30	0·157	4589
3	16	27	74	1·74	0·35	0·241	6008
4	17	35	69	1·61	0·37	0·225	4644
5	19	30	67	1·69	0·37	0·285	8345
6	19	32	51	1·52	0·36	0·178	5019
7	20	22	47	1·59	0·35	0·206	5871
8	21	20	58	1·65	0·30	0·222	6302
9	21	40	78	1·63	0·26	0·231	6498
10	22	25	46	1·52	0·33	0·170	5021
11	23	18	58	1·65	0·35	0·226	6387
12	23	18	53	1·57	0·28	0·145	4193
13	23	25	56	1·60	0·35	0·148	4406
14	24	37	59	1·49	0·36	0·186	5133
15	24	35	70	1·67	0·36	0·257	7573
16	24	37	89	1·63	0·37	0·297	8519
17	24	21	65	1·56	0·34	0·189	5465
18	24	35	57	1·49	0·32	0·232	6483
19	25	36	56	1·61	0·35	0·156	4368
20	25	21	51	1·55	0·29	0·170	5063
21	25	28	66	1·66	0·34	0·183	5266
22	26	35	70	1·55	0·36	0·259	7255
23	26	21	65	1·57	0·35	0·106	7121
24	26	30	65	1·66	0·35	0·213	6067
25	27	25	70	1·55	0·37	0·294	5116
26	27	31	71	1·65	0·36	0·201	5669
27	27	34	55	1·54	0·37	0·451	4644
28	27	29	52	1·55	0·35	0·151	4598
29	28	30	57	1·57	0·35	0·192	5682
30	29	21	55	1·64	0·37	0·167	4892
31	29	30	56	1·57	0·35	0·192	5682
32	30	30	79	1·60	0·38	0·252	7392
33	30	26	62	1·49	0·36	0·173	5222
34	31	30	55	1·50	0·30	0·184	5289
35	31	26	63	1·66	0·37	0·203	5832
36	31	28	59	1·62	0·34	0·255	7326
37	32	18	68	1·67	0·33	0·227	6362
38	33	31	55	1·54	0·39	0·249	7049
39	34	24	63	1·65	0·36	0·209	6158
40	34	22	52	1·57	0·32	0·176	5196
41	34	26	65	1·65	0·35	0·254	7121
Mean	25·32	27·9	61·85	1·66	0·35	0·203	5876
SD	5·36	6·1	9·35	6·08	3·0	0·05	1226

PCV, packed cell volume; $\dot{V}_{O_2}$, oxygen consumption; BMR, basal metabolic rate.